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(n, charged particle) Reactions on 1p-shell Nuclides at 14MeV

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1. Introduction

The reactions (n,p), (n,d), (n,t) and (n,α) of 14-MeV neutrons with 1p-shell nuclides are of interest in several areas: They can provide tests of charge symmetry by comparisons with proton-induced reactions (on T=0 nuclides); they allow study of the complex, often many-body decay of excited nuclear states; and they yield information on final-state interactions.

Previous studies have investigated these reactions in kinematically complete experiments, usually with poor statistics, via nuclear emulsions or cloud chamber techniques. Other studies have been based on charged-particle detectors of various types. Both approaches have been limited however, by neutron-induced backgrounds and detection thresholds in the charged-particle spectra.

As part of our program in (n, charged particle) reaction studies, we have investigated several 1p-shell nuclides: ^{9}Be, ^{12}C, ^{14}N, and ^{16}O at E_n = 14MeV (Haight et. al. 1981). These measurements, with the newly developed magnetic quadrupole charged-particle spectrometer, provide data with a much higher signal-to-background than heretofore available.

2. Experimental Method

Neutrons of 14 MeV were produced by the LLNL rotating target neutron source with a source strength of 2 10^{12} neutrons/sec. These neutrons irradiated foils placed 7cm or more from the neutron source. The charged-particle reaction products from the foils were detected with a magnetic quadrupole charged-particle spectrometer (Alvar et. al. 1978), which is based on a magnetic triplet lens for transporting the charged particles to a detector 2.65m from the irradiated foil. The detector consisted of two proportional ΔE counters and a silicon surface-barrier counter to provide a triple coincidence signal. Foils used in these experiments were especially thin to allow low energy alpha particles to escape with little energy loss: ^{9}Be (.25mg/cm), ^{12}C(.17 mg/cm^2), ^{14}N in the form of Ta_yN_x (.06 mg/cm^2 of N) and ^{16}O in the form of WO_3 (.06 mg/cm^2 of O). Somewhat thicker foils were used for the higher alpha-particle energies and for proton-, deuteron- and triton-emission studies. Charged particles were detected if they had energy greater than 1 MeV.

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3. Results and Discussion

Typical spectra are given in Figs. 1 and 2 for the alpha particles from ^{9}Be and ^{12}C. In the former case, evidence is found for population of the ^{6}He ground and 2_{+} states. For the latter, both the ground and 2.4MeV states of ^{9}Be are seen to be populated. In both spectra, however, the majority of alpha particles come from other decay processes, presumably many-body breakup.

It is interesting to note how similar the alpha-particle spectrum from 14MeV neutrons on ^{12}C is to that for protons of similar energy on the same target nuclide(Bauer et. al. 1964).

The many-body breakup spectra can be analyzed by a sequential decay model as shown, for example, by Antolkovic and Dolenec(1975) for 14-MeV neutrons on ^{12}C. Inelastic scattering (neutron decay of the compound nucleus) is the dominant first stage in most of these reactions. Nucleon-nucleus scattering data from several sources indicate the population of certain intermediate states; for example the 7.65MeV state of ^{12}C is not populated strongly by inelastic scattering, but the 9.64MeV state is much more important. We must make assumptions about the importance of other states as well as about branching ratios and angular distributions of the emitted particles. When the known branching ratios and inelastic scattering data are combined with reasonable assumptions, we are able to reproduce most of these charged particle spectra and their angular distributions.

References

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Bauer RW, Anderson JD and Wong C 1964 Nucl. Phys. 56 117

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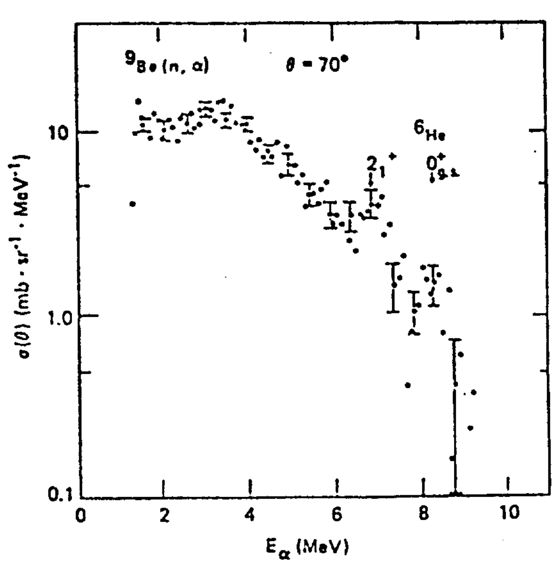

Fig.1 Cross section for alpha-particle emission at 70° for ^{9}Be under bombardment by 14-MeV neutrons.

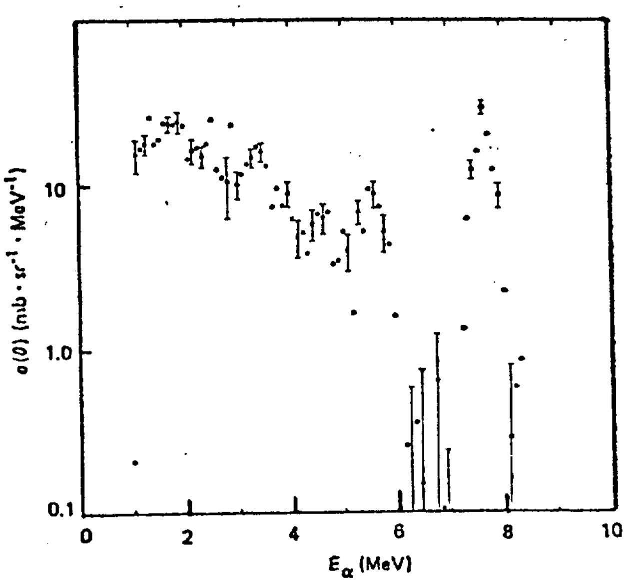

Fig.2 Cross section for alpha-particle emission at 30° for ^{12}C under bombardment by 14-MeV neutrons.